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Architecture and Building Systems

CBDM, metrics, and level of detail

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https://dx.doi.org/10.5281/zenodo.8314773

Background

Nima's presentation in the previous session: Nima Forouzandeh. *Influence of inaccurate material optical properties and geometrical levels of detail on daylight simulation results - sensitivity analysis and uncertainty quantification*. 21st International Radiance Workshop, Innsbruck, Austria. Aug. 2023

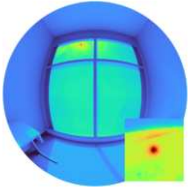
- Context: Research in daylight metrics for dwellings
- What can metrics tell if they are computed from incomplete models
- Assumption: Furnishing etc. is unknown during building design

To be published soon: L.O. Grobe and J.A. Jakubiec. "Impact of model detail on daylighting metrics in residential buildings". In: *Proceedings of CISBAT2023*. In press.

Refinements and CBDM

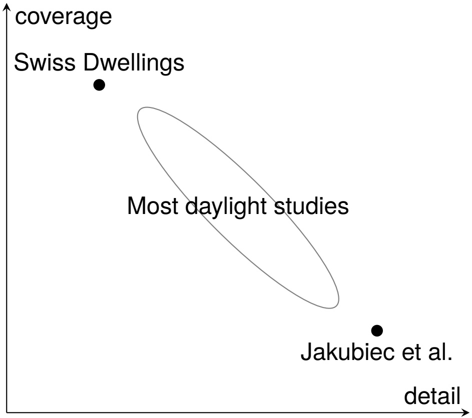
Sky subdivisions, solar models, X-Phase-Methods Andy McNeil. *BSDFs, matrices and phases*. 13th International Radiance Workshop. London, UK, Sept. 2014

Fenestration: Data-driven BSDF Gregory J. Ward et al. "Modeling specular transmission of complex fenestration systems with data-driven BSDFs". In: *Building and Environment* 196 (2021), p. 107774. ISSN: 0360-1323. DOI: 10.1016/j.buildenv.2021.107774



Positions: RAYTRAVERSE Stephen W Wasilewski et al. "Raytraverse: Navigating the lightfield to enhance climate-based daylight modeling". In: *Proceedings SimAUD 2021*. 2022. in press

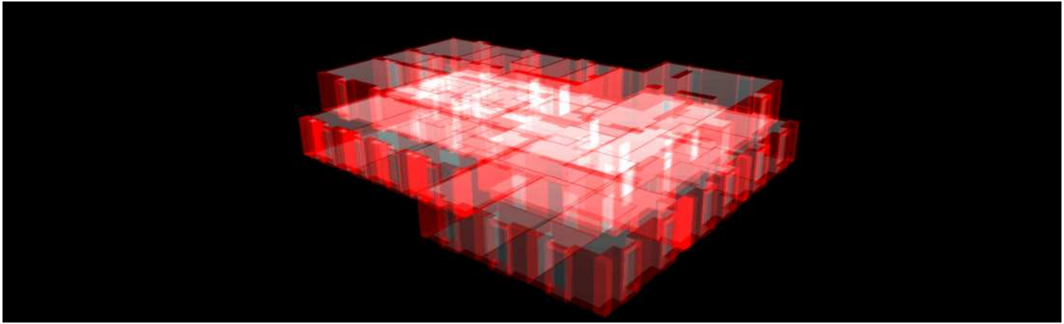
Level of Detail versus data availability



Swiss Dwellings: Matthias Standfest et al. *Swiss dwellings: A large dataset of apartment models including aggregated geolocation-based simulation results covering viewshed, natural light, traffic noise, centrality and geometric analysis*. Zenodo. 2022. DOI: 10.5281/zenodo.7070951

J.A. Jakubiec et al. “Subjective and measured evidence for residential lighting metrics in the tropics”. In: *Building Simulation Conference*. Vol. 2. 2019

Swiss Dwellings



- $42\,207$ apartments in 3093 buildings comprising $242\,257$ rooms
- Geometry described by *Well-Known Text* (WKT)
- Conversion to Wavefron OBJ is possible
- Room typologies and daylight characteristics as room attributes
- No materials, no shading, no furnishing!

Recommendations

Daylight in buildings. Standard EN 17037:2018. CEN / TC 169, June 2019:

> *Daylight calculation should take into account (...) external surroundings, daylight openings (materials and components), and internal reflections (e.g. indoor surfaces and fixed objects). (...) If details of the space being assessed are not available, then reasonable assumptions may be employed (e.g reflectance of indoor surfaces, indoor space configurations and furniture, if known). All assumptions made shall be stated.*

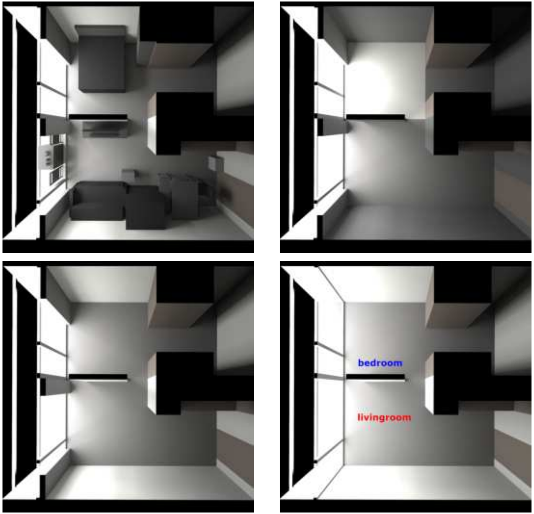
Approved method: IES Spatial Daylight Autonomy (SDA) and Annual Sunlight Exposure (ASE). Recommendation LM-83-12. IES, Oct. 2012

> *Furniture and opaque interior partitions shall be modeled. Any partition or furniture element extending 36" above the floor or more shall be modeled to within 6" accuracy. If furniture layout and type are not known precisely, a typical furniture layout for that space type should be used. (...) Discussion: The location, geometry and reflectance of interior obstructions have an important influence on daylight distribution. For example, lowering the height of open office partitions from 60" to 45" can result in a* $20\,\%$ *increase in daylight availability in spaces with large windows.(...)*

Detailed data from post-occupancy surveys

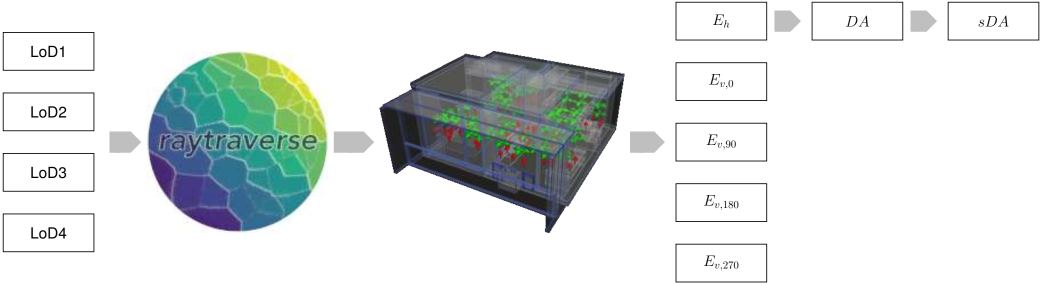
3D scans Alstan J.A. Jakubiec et al. "Subjective and measured evidence for residential lighting metrics in the tropics". In: *Building Simulation Conference*. Vol. 2. 2019

~~Three~~ Four LoDs



- LoD4 Detailed model based on 3D scan, including building shell, environment, shades, and furniture
- LoD3 As LoD4, but without furniture and wall reflectivity reduced to $\rho = 0.2$ to account for occlusion of wall surfaces
- LoD2 As LoD4, but without furniture
- LoD1 Only building shell and environment

Simulation with Raytraverse



Stephen W Wasilewski et al. “Raytraverse: Navigating the lightfield to enhance climate-based daylight modeling”. In: *Proceedings SimAUD 2021*. 2022. in press

Technicalities: Evaluating Raytraverse results 1

RAYTRAVERSE saves its results in packed NUMPY arrays:

```
import numpy as np
```

Load the archive and show its contents:

```
npz = np.load(npzFile)
print(npz.files)
['names', 'bnd_0', 'bnd_1', 'bnd_2', 'data_0', ... ,
    'data_4372', 'arr_0', 'arr_1', 'arr_2', 'arr_3']
```

Print the names of arrays arr_0 to arr_3:

```
print(npz['names'])
['sky' 'zone' 'view' 'metric']
```

Technicalities: Evaluating Raytraverse results 2

Access the time stamps (month / day / hour of day):

```
print(npz['arr_0'])
[( 1.,  1.,  7.5) ( 1.,  1.,  8.5) ( 1.,  1.,  9.5) ...
 (12., 31., 17.5) (12., 31., 18.5)]
```

Access the view directions ($\vec{dx}, \vec{dy}, \vec{dz}$):

```
print("npz['arr_2'])
[( 0.11440395,  0.99343431, 0.) (-0.99343431,  0.11440395, 0.)
 ( 0.11440395, -0.99343431, 0.) ( 0.99343431, -0.11440395, 0.)]
```

Technicalities: Evaluating Raytraverse results 3

Now we can have a look at the second time-step:

```
print("npz['data_1'].shape)
(59, 4, 10)
print(npz['arr_3'])
['x' 'y' 'z' 'area' 'illum' 'avglum' 'gcr' 'dgp' 'log_gc' 'maxlum']
```

... and read the point illuminances for the first view direction:

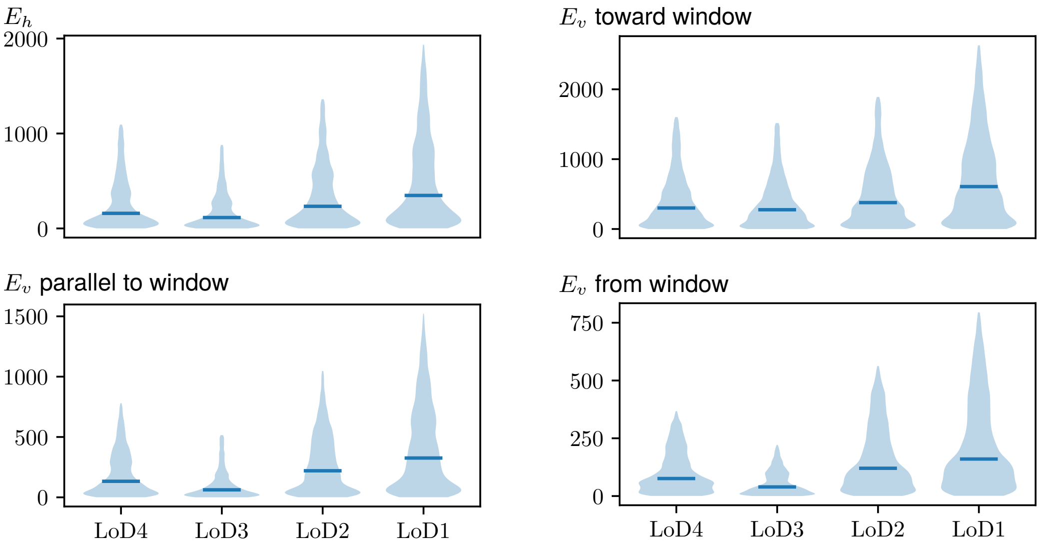
```
print (npz['data_1'][:,0,4])
```

Spatial averaging

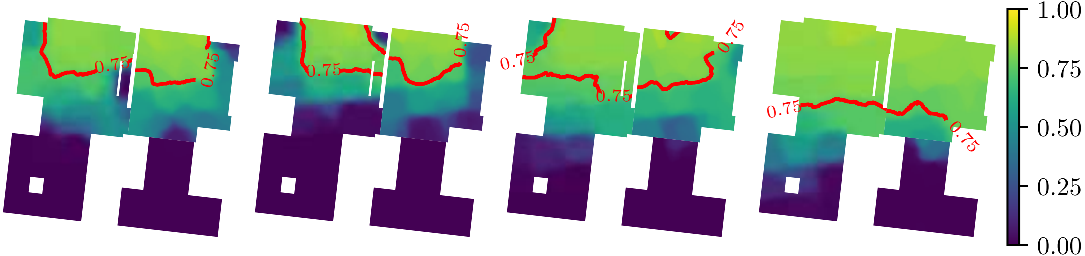
Note the adaptive resolution – points represent different areas of the zone. Therefore, spatial averaging typically requires prior weighing with the *area*!

From here on, all processing is done with NUMPY, MATPLOTLIB and friends.

Frequency distributions of Eh, Ev



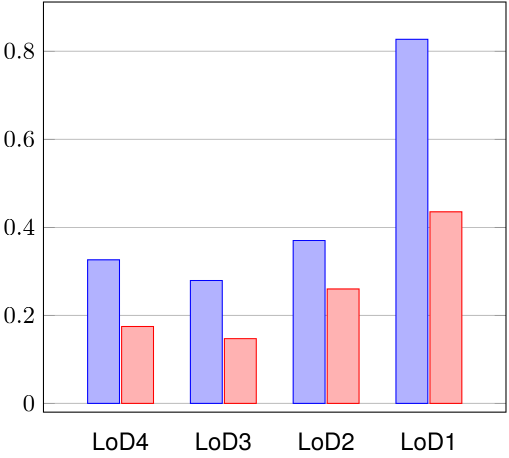
Daylight provision

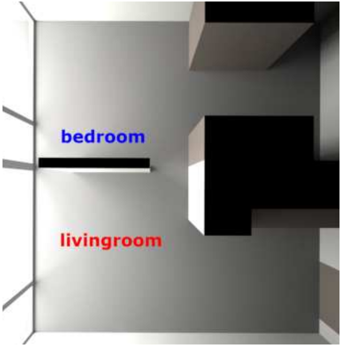


- Daylight Autonomy sDA[1] was calculated for sensors at $z = 0.80$ m with a threshold of 300 lx.
- Red line indicates the area meeting the criteria for $75\,\%$ of daylight hours.

[1] The legend shows sDA/DA as fraction 0 to 1 instead of percentage.

Ranking two rooms by sDA





Comparison of bedroom (blue) and living room (red) by sDA

And what about glare?

- Daylight Glare Probabilty DGP was calculated for sensors at $z = 1.60\,\mathrm{m}$ toward four directions.
- Color indicates the fraction of daylight hours with $DGP \geq 0.35$ by evaluating the worst of the four directions.
- Red line indicates the area meeting the criteria for $95\,\%$ of daylight hours.
- But: The chosen example exhibits almost no glare conditions due to the combination of overhang. North orientation, and location close to the equator.

Conclusions

- LoD moderately effected E_h and derived sDA.
- Moderate effect on E_v toward window for LoD2 to LoD4 (as long as shading is modelled).
- Strong effect on E_v parallel to and facing away from window.
- Relative ranking of two rooms was consistent for all LoDs.
- Luminance-based metrics to be done.
- Expanding to include more cases necessary for representative results.

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